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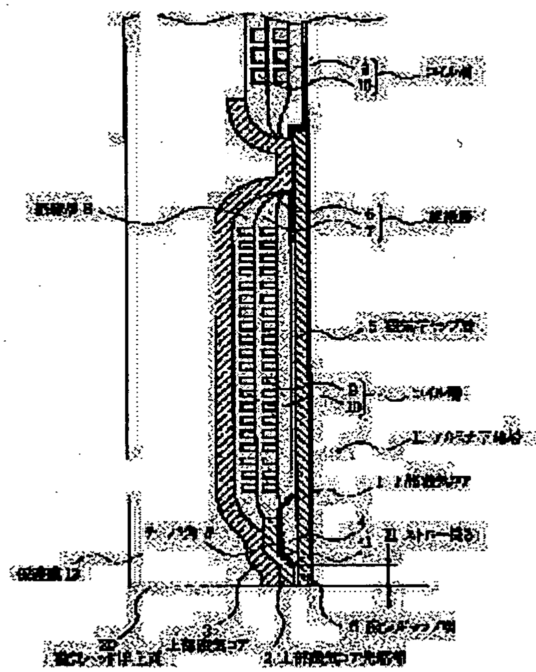
(54) THIN-FILM MAGNETIC HEAD AND ITS PRODUCTION AS WHEEL AS MAGNETIC MEMORY DEVICE

(57)Abstract:



PURPOSE: To obtain a thin-film magnetic head having excellent characteristics and a magnetic memory device formed by using the same by subjecting magnetic cores to a heat treatment at a temp. higher than the thermal decomposition temp. of insulating film.

CONSTITUTION: The front end 2 of the upper magnetic core extends from a magnetic head floating surface 20 through the part of a throat length 21 onto a nonmagnetic spacer 4. The lower magnetic core 1 and the front end 2 of the upper magnetic core are Fe-Ta-N film which is heat-treated at 400 to 600° C after film formation and has a high saturation magnetic flux density. The heat treatment of the Fe-Ta-N film is executed prior to the formation of insulating layers 6, 7, 8 which are polymer films and the upper magnetic core 3 which is a 'Permalloy (R)' film. Thereby, the heat treatment of the Fe-Ta-N films at a temp. higher than the thermal decomposition temp. of the insulating layers prior to the formation of the insulating layers is made possible and the thin-film magnetic head provided with a soft magnetic film having the excellent characteristics and polymer insulation films is obtd. The magnetic memory device having the high recording density is obtd. by combining such thin-film magnetic head and the magnetic recording medium having the high coercive force.

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CLAIMS

[Claim(s)]
[Claim 1] Temperature T1 Heat-treated saturation magnetic flux density Bs1 Magnetic film A1 Temperature T2 Heat-treated saturation magnetic flux density Bs2 Magnetic film A2 (however, T2 <T1 and Bs2 <Bs1), In the thin film magnetic head which has a nonmagnetic gap layer with a thickness of 1 micrometer or less, a thin film coil pattern, and the insulating layer that consists of a poly membrane The aforementioned magnetic film A1 It exists in the lower part and the upper part of the aforementioned nonmagnetic gap layer. And in the upper part of the aforementioned poly membrane insulating layer, it is the aforementioned magnetic film A2. It exists through a direct or nonmagnetic gap layer, and is the aforementioned magnetic film A1. The aforementioned magnetic film A2 The thin film magnetic head characterized by having connected through the direct or aforementioned nonmagnetic gap layer.
[Claim 2] The aforementioned heat treatment temperature T1 The thin film magnetic head according to claim 1 characterized by being higher than the pyrolysis temperature of the aforementioned insulating layer.
[Claim 3] The aforementioned magnetic film A1 of two upper and lower sides which oppose through the aforementioned nonmagnetic gap layer at back of a magnetic-head surfacing side The thin film magnetic head according to claim 1 or 2 characterized by having the nonmagnetic spacer which consists of an inorganic substance with a thickness of 1 micrometers or more in between.
[Claim 4] The aforementioned magnetic film A1 The aforementioned magnetic film A2 Connection area is the aforementioned magnetic film A2. The thin film magnetic head of three given in any 1 term from the claim 1 characterized by being larger than the minimum cross section in the cross section which intersects perpendicularly in the direction in which signal magnetic flux flows.
[Claim 5] The aforementioned magnetic film A1 The thin film magnetic head of the claims 1-4 characterized by being the X-Y-Z ternary alloy containing three elements of X= {Fe, Co}, Y= {Ta, Zr, Nb, aluminum}, and Z= {N, C}, or an alloy more than a 4 yuan system given in any 1 term.
[Claim 6] The aforementioned magnetic film A2 The thin film magnetic head of four given in any 1 term from the claim 1 characterized by being nickel-Fe (permalloy), nickel-Fe (permalloy) system plural alloys, or Co system amorphous alloy.
[Claim 7] It is the manufacture method of the thin film magnetic head of seven given in any 1 term from a claim 1, and is the aforementioned magnetic film A1. They are the aforementioned macromolecule insulating layer and the aforementioned magnetic film A2 after heat treatment. The manufacture method of the thin film magnetic head characterized by forming.
[Claim 8] Magnetic storage characterized by having had the thin film magnetic head of seven given in any 1 term, and the magnetic-recording medium of 2500 or more oersteds of coercive force from the claim 1, and setting the surfacing crevice between the aforementioned thin film magnetic heads to 0.03 micrometers or more.
[Claim 9] Magnetic storage characterized by having had the thin film magnetic head of seven given in any 1 term, and the magnetic-recording medium of 2200 or more oersteds of coercive force from the claim 1, and setting the surfacing crevice between the aforementioned thin film

magnetic heads to 0.07 micrometers or more.
[Claim 10] Magnetic storage characterized by having the thin film magnetic head of seven given in any 1 term, and the magnetic-recording medium of 2800 or more oersteds of coercive force from a claim 1.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the thin film magnetic head which it stands in a line and is used for the magnetic storage for computers about the thin film magnetic head and its manufacture method, and the magnetic storage using this thin film magnetic head, and its manufacture method.
[0002]
[Description of the Prior Art] Conventionally, many permalloy films from which this kind of thin film magnetic head was mainly made with electroplating as a magnetic-core material are used. However, in order to give the write-in capacity to the magnetic-recording medium of high coercive force recordable high-density further to the magnetic head from now on, it is necessary to adopt what has the larger flux density as a magnetic-core material than the saturation magnetic flux density (0.8-1.0T) of a permalloy.
[0003] The magnetization changes length of the magnetic-recording medium which is one of the factors which determines the upper limit of magnetic recording density is dependent on a magnetic field and magnetic field inclination in case the recording point of a magnetic-recording medium keeps away from the gap of the magnetic head. Therefore, only the point of an up magnetic core (magnetic-head back end side) of being required of core materials, in order to raise recording density at least is making it high saturation magnetic flux density.
[0004] Drawing 4 is the cross section showing an example of the conventional thin film magnetic head which used the high saturation-magnetic-flux-density magnetic film.
[0005] the magnetic gap 5 which the conventional thin film magnetic head has the lower magnetic core 31 which consists of a permalloy film in contact with the alumina ground layer 111, and the lower magnetic-core point 32 which consists of a magnetic film which has saturation magnetic flux density higher than a permalloy, and is non-magnetic material on these when drawing 4 is referred to, and a conductor -- the coil layers 9 and 10 are arranged A magnetic gap 5 generates a record magnetic field for an about 0.1-1.0-micrometer magnetic crevice by formation ****** at the time of writing between the up magnetic-core point 33 and the lower magnetic-core point 32, and introduces the signal magnetic flux from a medium into a magnetic core at the time of read-out.
[0006] next, a conductor -- the coil layers 9 and 10 are formed by the well-known pattern galvanizing method, and Cu is used as a material Insulating layers 6, 7, and 8 are the poly membranes formed by the pattern of the photoresist which baked. and a conductor -- the coil layers 9 and 10 are surrounded by insulating layers 6, 7, and 8 on an insulating layer 8, the up magnetic core 34 which consists of an up magnetic-core point 33 which consists of a high saturation-magnetic-flux-density magnetic film, and a permalloy arranges -- having -- the lower magnetic core 31 and the lower magnetic-core point 32 -- a conductor -- the magnetic circuit interlinked with the coil layers 9 and 10 is formed Thus, the constituted thin film magnetic-head element is covered by the protective coat 12 of an alumina.
[0007] As invention about the thin film head which used the high saturation-magnetic-flux-density magnetic film for a part of magnetic core by composition mentioned above, the

technology using the soft-magnetism film which is high saturation magnetic flux density is indicated from the back core portion of a NiFe film by the magnetic-core layer which faces the magnetic-recording medium side of a magnetic gap at JP,3-144907,A. According to this, Fe-Co-nickel ternary alloy or the Fe-Co-nickel-Cr system alloy of 4 yuan is formed by the galvanizing method as a high saturation-magnetic-flux-density soft-magnetism film.
[0008] Moreover, the technology of making an up magnetic pole or a lower magnetic pole exposing only the member of high saturation magnetic flux density to a confrontation side with a magnetic-recording medium as other examples at JP,3-029104,A using the two-layer cascade screen which consists of an amorphous alloy or a multilayer magnetism alloy is indicated.
[0009]
[Problem(s) to be Solved by the Invention] In these conventional thin film magnetic heads, since poly membranes, such as a photoresist which baked to the insulating layer, are used, in order to prevent the pyrolysis of this poly membrane, there is a fault that the magnetic material and the manufacture method of using for an up magnetic-core point are limited.
[0010] Although the photoresist which constructed the bridge with baking becomes the outstanding insulator layer, the grade of a pyrolysis will become intense if it becomes 300 degrees C or more. Therefore, heat treatment according to the temperature of 300 degrees C or more to the up magnetic core which forms membranes after insulator layer formation is difficult. Moreover, if a suitable polyimide poly membrane is used instead of a photoresist, although pyrolysis temperature will rise, a pyrolysis will be caused if it becomes 400 degrees C or more also by that case.
[0011] In order to avoid such a pyrolysis, using inorganic material, such as an alumina (aluminum 2O3), is also considered instead of the photoresist which baked as an insulating-layer material. However, in this case, patterning of the inorganic material with a thickness of several micrometers - about twenty micrometers must be carried out, and there is a fault that manufacture becomes difficult compared with the case where the photoresist which baked is used.
[0012] On the other hand, many of soft magnetic materials can obtain ********** which was excellent for the first time in many cases by performing suitable heat treatment. For example, in the film of iron system microcrystal material, such as Fe-Ta-N and Fe-Ta-C, in order to pull out outstanding ********** called saturation magnetic flux density 1.5-1.8T and relative permeability 3000-6000, it is necessary to heat-treat above 400 degrees C. However, in the thin film magnetic head with the conventional macromolecule insulating layer, ********** which was excellent even if heat treatment at 400 degrees C or more used these soft-magnetism films as eye an impossible hatchet and a magnetic-core material cannot fully be pulled out.
[0013] The purpose of this invention is to offer the thin film magnetic head equipped with the soft-magnetism film which solves the fault mentioned above, makes it possible to heat-treat the elasticity magnetic film of hot and high saturation magnetic flux density rather than the pyrolysis temperature of a macromolecule insulator layer before formation of a macromolecule insulator layer, and has the outstanding property, and the macromolecule insulator layer, and the magnetic storage using this thin film magnetic head.
[0014]
[Means for Solving the Problem] this invention -- temperature T1 Heat-treated saturation magnetic flux density Bs1 Magnetic film A1 Temperature T2 Heat-treated saturation magnetic flux density Bs2 Magnetic film A2 (however, T2 <T1 and Bs2<Bs1), In the thin film magnetic head which has a nonmagnetic gap layer with a thickness of 1 micrometer or less, a thin film coil pattern, and the insulating layer that consists of a poly membrane The aforementioned magnetic film A1 It exists in the lower part and the upper part of the aforementioned nonmagnetic gap layer. And in the upper part of the aforementioned poly membrane insulating layer, it is the aforementioned magnetic film A2. It exists through a direct or nonmagnetic gap layer, and is the aforementioned magnetic film A1. The aforementioned magnetic film A2 It is characterized by having connected through the direct or aforementioned nonmagnetic gap layer.
[0015] Moreover, the aforementioned heat treatment temperature T1 The aforementioned magnetic film A1 of two upper and lower sides which are characterized by being higher than the

pyrolysis temperature of the aforementioned insulating layer, and oppose through the aforementioned nonmagnetic gap layer at back of a magnetic-head surfacing side In between It is characterized by having the nonmagnetic spacer which consists of an inorganic substance with a thickness of 1 micrometers or more, and is the aforementioned magnetic film A1. The aforementioned magnetic film A2 Connection area is the aforementioned magnetic film A2. It is characterized by being larger than the minimum cross section in the cross section which intersects perpendicularly in the direction in which signal magnetic flux flows.

[0016] And the aforementioned magnetic film A1 X-Y-Z ternary alloy containing three elements of X= {Fe, Co}, Y= {Ta, Zr, Nb, aluminum}, and Z= {N, C}, or the alloy more than a 4 yuan system -- you may be -- moreover, the aforementioned magnetic film A2 You may be nickel-Fe (permalloy), nickel-Fe (permalloy) system plural alloys, or Co system amorphous alloy, and these thin film magnetic heads are the aforementioned magnetic films A1. They are the aforementioned macromolecule insulating layer and the aforementioned magnetic film A2 after heat treatment. It is characterized by forming.

[0017] Furthermore, as magnetic storage, it has these thin film magnetic heads and the magnetic-recording medium of 2500 or more oersteds of coercive force, and the surfacing crevice between the aforementioned thin film magnetic heads is set to 0.03 micrometers or more. Or it has the thin film magnetic head and the magnetic-recording medium of 2200 or more oersteds of coercive force, and the surfacing crevice between the aforementioned thin film magnetic heads is set to 0.07 micrometers or more. Or you may have the thin film magnetic head and the magnetic-recording medium of 2800 or more oersteds of coercive force.

[0018]

[Example] Next, this invention is explained with reference to a drawing.

[0019] Drawing 1 is the cross section showing the 1st example of this invention. Reference of drawing 1 forms the lower magnetic core 1 of high saturation magnetic flux density which the 1st example becomes from the Fe-Ta-N film heat-treated at 400-600 degrees C after membrane formation in contact with the alumina ground layer 11. The thickness of this lower magnetic core 1 is 2-4 micrometers. Moreover, the magnetic-gap layer 5 is formed in contact with the lower magnetic core 1, and the nonmagnetic spacer 4 is further formed between the lower magnetic core 1 and the magnetic-gap layer 5.

[0020] The nonmagnetic spacer 4 is prolonged at back by length of about 5-25 micrometers from the part which only the distance of the throat length 21 separated from the magnetic-head surfacing side 20. This nonmagnetic spacer 4 uses the alumina which carried out spatter membrane formation. The thickness of this nonmagnetic spacer 4 is 1-4 micrometers, extends the interval of the lower magnetic core 1 and the up magnetic-core point 2, and is raising magnetic-flux efficiency by reducing disclosure of magnetic flux in the meantime.

[0021] In addition, the taper is provided in the edge 41 of a nonmagnetic spacer so that magnetic properties may not deteriorate with a level difference with the rapid up magnetic-core point 2. As for this taper angle theta, it is desirable that it is 60 degrees or less, and it is more more desirable still that the taper angle theta is 45 degrees or less.

[0022] The up magnetic-core point 2 is prolonged on the nonmagnetic spacer 4 via throat length 21 portion from the magnetic-head surfacing side 20. Besides, the section magnetic-core point 2 carries out patterning of the Fe-Ta-N film of high saturation magnetic flux density heat-treated at 400-600 degrees C after membrane formation, and the thickness is 2-4 micrometers.

[0023] Although heat treatment of the Fe-Ta-N film used for the lower magnetic core 1 and the up magnetic-core point 2 may be performed simultaneously, it is necessary to carry out before formation of insulating layers 6, 7, and 8. The pattern of the photoresist made to construct a bridge by baking at 200-300 degrees C as an insulating-layer material is used for this, and this material is based on the reason for pyrolyzing by heat treatment of 300 degrees C or more.

[0024] Next, the up magnetic core 3 is placed in contact with the insulating layer 8 of the up magnetic-core point 2 and the topmost part. The field where the up magnetic-core point 2 and the up magnetic core 3 touch is the permalloy film pattern formed with well-known pattern plating technology. This permalloy film pattern shows a sufficiently stable high permeability property (relative permeability > 2000) with heat treatment of 300 degrees C or less among a

magnetic field. Moreover, the thickness of the up magnetic core 3 is 3-6 micrometers, and is thicker than the up magnetic-core point 2.

[0025] Although the saturation magnetic flux density (0.8-1.0T) of a permalloy film is smaller than an Fe-Ta-N film, it can avoid the magnetic saturation in the up magnetic core 3 by thickening this thickness. Moreover, in order to lose disclosure of the signal magnetic flux in the connection of the up magnetic-core point 2 and the up magnetic core 3, it is necessary to make the length of a connection larger than the thickness of the up magnetic-core point 2 and the up magnetic core 3.

[0026] In addition, the same effect is acquired by using the iron system microcrystal film material which shows ********** excellent in heat treatment more than the pyrolysis temperature of insulator layers, such as not only an Fe-Ta-N film but a Fe-Ta-C film, an Fe-Zr-N film, etc., as a high saturation-magnetic-flux-density film material used for the lower magnetic core 1 and the up magnetic-core point 2.

[0027] the same effect will be acquired if the microcrystal film material from which ********** which was generally excellent in the X-Y-Z plural systems containing X= {Fe, Co}, Y= {Ta, Zr, Nb, aluminum}, and Z= {N, C} with heat treatment is obtained is used (here -- X, Y, and Z -- {-- } -- one or more kinds of inner elements are expressed)

[0028] furthermore, the thing for which the same effect as **** will be acquired if the material which can improve ********** with heat treatment by temperature higher than the pyrolysis temperature of not only iron system microcrystal material but a macromolecule insulator layer as a material of the lower magnetic core 1 and the up magnetic-core point 2 is used -- obvious -- it is .

[0029] Moreover, the same effect is acquired even if it uses plating films other than the permalloy from which ********** which excelled the pyrolysis temperature of not only a permalloy plating film but a macromolecule insulator layer in low heat treatment temperature is obtained, and Co system amorphous film material created by the spatter as a material of the up magnetic core 3.

[0030] Next, the 2nd example of this invention is explained.

[0031] Drawing 2 is the cross section showing the 2nd example of this invention. Except up magnetic-core 103, the 2nd example is the same composition as the 1st example, in order that it may avoid duplication of explanation, explains only the structure of the up magnetic core 103, and omits it about others.

[0032] If drawing 2 is referred to, in the 2nd example, about 5-15 micrometers of edges 30 of the up magnetic core 103 formed by the Fe-Ta-N film exist in the back from the magnetic-head surfacing side 20. With this composition, since the low permalloy film of saturation magnetic flux density is not exposed to the magnetic-head surfacing side 20, the magnetic field inclination at the time of writing becomes sharp compared with the case of the 1st example. Therefore, the thin film magnetic head which was more suitable for high-density record is obtained.

[0033] In addition, in order to abolish the leakage of the signal magnetic flux in the up magnetic-core point 2 and the connection of the up magnetic core 103 also in this case, it is necessary to make the length of a connection thicker than the thickness of the up magnetic-core point 2 and the up magnetic core 103.

[0034] Next, the 3rd example of this invention is explained.

[0035] Drawing 3 is the cross section showing the 3rd example of this invention. The 3rd example is equipped with the coil [layer / coil / 9] 70 of the 3rd layer with which it insulated, and it was insulated by the insulating layer 60 in addition to ten for a high increase in power when drawing 3 was referred to.

[0036] Moreover, in the 3rd example, the crevice 40 with a depth of 1-4 micrometers is established in the alumina ground layer 110. the taper angle theta in the edge of this crevice 40 is 60 degrees or less -- ** -- it is desirable Moreover, by forming the lower magnetic core 101 in the form over this crevice 40, itself has the crevice, and if the taper angle theta becomes 60 degrees or more, degradation of the ********** of the lower magnetic core 101 will become remarkable.

[0037] The nonmagnetic spacer 104 is formed in the form where the crevice of the lower

magnetic core 101 is filled, by the alumina film. And in order to form the nonmagnetic spacer 104 with which only the crevice of the lower magnetic core 101 is fill uped exactly, after carrying out spatter membrane formation of the alumina film [a little] thicker than the depth of a crevice 40, flattening of the front face is carried out. The front face of the magnetic-gap layer 105 can be mostly made into flatness by using for flattening of this front face the wrapping (polish) technology which used well-known (Tin Sn) system surface plate and a well-known abrasive grain, or the etchback technology using the poly membrane.
[0038] In addition, in the 3rd example, in case spatter membrane formation of the Fe-Ta-N film of the up magnetic-core point 102 is carried out, the connection 50 of the lower magnetic core 101 in the back gap section and the up magnetic core 3 also performs spatter membrane formation by Fe-Ta-N simultaneously. Thereby, the level difference of the up magnetic core 3 was reduced, and degradation of the magnetic properties by the composition change in a pattern of the up magnetic core 3 etc. is prevented.
[0039] Moreover, this invention is applicable regardless of the number of layers of a coil so that this example may also show. That is, naturally it is applicable also to the thin film magnetic head which has the coil of four layers, and the thin film magnetic head of an one-layer coil.
[0040] The magnetic core of the thin film magnetic head offered by the structure and the manufacture method which were explained in each example mentioned above has saturation magnetic flux density and high permeability compared with the magnetic core manufactured only by the permalloy. Therefore, the magnetic storage of high recording density is realizable by combining with these thin film magnetic heads and the magnetic-recording medium of high coercive force. For example, as for the thin film magnetic head using the Fe-Ta-N film, write-in magnetic field strength will be about 1.5 times the thin film magnetic head of only a permalloy.
[0041] Information can be written in to the magnetic-recording medium of the big value of coercive force 2500 oersted, keeping the surfacing crevice between the thin film magnetic heads at 0.03 micrometers or more, and securing high reliability by this. Moreover, information can be written in also to the magnetic-recording medium of the big value of coercive force 2200 oersted, keeping the surfacing crevice between the thin film magnetic heads at 0.07 micrometers or more. And if a surfacing crevice is further made small and contact recording (contact record) is performed, informational writing is possible also to the magnetic-recording medium of 2800 or more oersteds of coercive force, and highly efficient magnetic-storage equipment can be offered.
[0042]
[Effect of the Invention] As explained above, the thin film magnetic head of this invention When an up magnetic core offers structure which is constitutionally arranged below a macromolecule insulator layer and its manufacture method of a layer While being able to offer the thin film magnetic head equipped with the soft-magnetism film and macromolecule insulator layer of the property which made it possible to heat-treat a high saturation-magnetic-flux-density elasticity magnetic film, and excelled the pyrolysis temperature of a macromolecule insulator layer in the elevated temperature before formation of a macromolecule insulator layer By combining this thin film magnetic head and the magnetic-recording medium of high coercive force, it is effective in the ability to offer the magnetic storage of high recording density.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the cross section showing the 1st example of this invention.
[Drawing 2] It is the cross section showing the 2nd example of this invention.
[Drawing 3] It is the cross section showing the 3rd example of this invention.
[Drawing 4] It is the cross section showing the conventional example.
[Description of Notations]
1 Lower Magnetic Core
2 Up Magnetic-Core Point
3 Up Magnetic Core
4 Nonmagnetic Spacer
5 Magnetic-Gap Layer
6, 7, 8 Insulating layer
9 Ten Coil layer
11,110,111 Alumina ground layer
12 Protective Coat
20 Magnetic-Head Surfacing Side
21 Throat Length
30 Edge of Up Magnetic Core
31 Lower Magnetic Core
32 Lower Magnetic-Core Point
33 Up Magnetic-Core Point
34 Up Magnetic Core
40 Crevice
41 Edge of Nonmagnetic Spacer
50 Connection
60 Insulating Layer
70 Coil of the 3rd Layer
101 Lower Magnetic Core
102 Up Magnetic-Core Point
103 Up Magnetic Core
104 Nonmagnetic Spacer
105 Magnetic-Gap Layer

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